Vol. 37 No 3

BULLETIN

OF THE

TORREY BOTANICAL CLUB

MARCH, 1909

# The study of winter buds with reference to their growth and leaf content *

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(WITH PLATES 9–11)

The growth of buds in winter has been the subject of much speculation and discussion by the botanist and by the casual observer. This speculation and discussion, stimulated by an occasional winter of unusual mildness, has given rise to various theories about the disturbance of that quiescent state, or winter rest-period, which has stamped itself so indelibly on the trees and shrubs of our temperate zones. Inquiry into these theories, especially those relating to the winter growth of buds, discloses the fact that there has been comparatively little investigation or careful observation to substantiate them. The scattered statements which have crept into literature are, as a rule, merely opinions or passing observations made in the course of investigation of other phenomena.

Askenasy (1877) found some evidence of the growth of buds in winter. He says that the so-called period of rest, extending from about the first of November to the beginning of February, is one of extremely slow growth, a growth which in November becomes almost *nil*. His investigations, however, cover the rest period of but one species of our trees, *Prunus Avium*, the wild cherry, and include the study of the flower buds alone.

* Awarded the second prize by the Boston Society of Natural History in the Walker Prize Competition for 1908.

[The BULLETIN for February, 1909 (36: 55–116. *pl. 1–8*) was issued 4 Mr 1909.]

From the investigations of Fischer (1891) and others, there is evidence that certain activities and various metabolic processes take place within the winter bud. Fischer claimed that to the external periodicity revealed in the phenomena of growth there is a corresponding internal periodicity in the processes of metabolism; that, in the buds and young shoots, movements and changes in the reserve material take place during the cool and cold seasons; and that these activities are dependent not only upon temperature but upon the inherent tendencies of the plant.

The results of Fischer's investigation would admirably supplement those of Askenasy had the latter considered a greater variety of plants. The study of flower buds of *Prunus Avium* alone can scarcely serve as a type for the growth of the leaf buds of all our trees and shrubs.

The problem of growth in the leaf bud during winter presents two important subjects for scientific research,—the question of growth, in so far as it relates to the enlargement of tissue through the addition of new cells or the stretching of cells already formed, and the question of leaf content dealing with the formation of additional leaf fundaments. These problems are considered in the present investigation.

## METHODS

*Material:* As a basis for this study, observations and investigations have been made on the following twenty-two species, including seventeen different genera, of the common trees and shrubs of Wellesley, Massachusetts:

*Fagus americana* L. (American beech).
*Fagus sylvatica* L. (European beech).
*Syringa vulgaris* L. (lilac).
*Ulmus americana* L. (American elm).
*Alnus incana* Willd. (speckled alder).
*Fraxinus americana* L. (white ash).
*Tilia vulgaris* Hayne.
*Tilia americana* L. (basswood).
*Acer platanoides* L. (Norway maple).
*Populus tremuloides* Michx. (American aspen).
*Betula populifolia* Marsh. (American white birch).
*Hicoria ovata* Britton (shag-bark).

*Hicoria microcarpa* Britton (small-fruited hickory).
*Salix fragilis* L. (brittle willow).
*Salix alba* L. (white willow).
*Aesculus Hippocastanum* L. (horse-chestnut).
*Quercus alba* L. (white oak).
*Quercus rubra* L. (red oak).
*Picea excelsa* Link (Norway spruce).
*Liriodendron Tulipifera* L. (tulip-tree).
*Rhododendron maximum* L. (great laurel).
*Philadelphus* (mock orange).

### DETERMINATION OF BUD CONTENT

For the study of leaf content, normal branches, upper and lower ones from various parts of the tree or shrub, were taken and studied during the months of November and December, 1905 and 1906. A long pruning shears was used to reach the upper branches. The number of nodes was counted and recorded for each season's growth, two and, where practicable, three years back. By this method a record of the number of leaves which were developed during those seasons was obtained. The terminal or upper axillary bud of each shoot, the nodes of which had been counted, was examined with a dissecting microscope, and the number of leaves found in the bud was noted.

### FIELD OBSERVATIONS ON GROWTH

Observations on the growth of the bud were carried on during all of the winter and spring months. Ten normal buds of each genus were marked with a nurseryman's wooden label. During the latter half of November, 1905, and each month thereafter until the unfolding of the leaves in April or May, these buds were measured for the greatest length and the greatest diameter in each case. Measurements in length were made with a steel spacing dividers; measurements in diameter, with a micrometer screw caliper graduated to 0.01 mm. During the months of February, March, and April, measurements were made twice a month, once at the beginning and once at the close. Data resulting from these measurements, about 3000 in all, form the basis of the curves of growth as well as of the deductions on dormancy and growth in the gross study of buds.

### MICROSCOPIC STUDY OF GROWTH

*Collecting:* Collections of material were made during the latter part of each month from November to April inclusive. Buds were cut from the high and low parts of each tree with the long pruning shears. The trees from which the buds were taken were situated in exposed and in sheltered places. In each case, however, the buds were cut from mature shrubs or trees and not from saplings or young growths.

*Fixing:* These methods are given in considerable detail because the varied character of the buds offered peculiar difficulties in fixing and cutting. In general, the bud scales were removed to the young leaves and the remainder of the bud was fixed entire. In the horse-chestnut the two outer whorls of leaves, and in the beech three lower leaves were also removed. Buds were placed directly in 20 per cent. alcohol and then passed successively through 40, 60, 80, 95 per cent. and absolute alcohol, remaining in each grade 24 hours. To insure perfect dehydration the absolute alcohol was changed once. The material was brought gradually into pure cedar oil by passing through the grades of alcohol and cedar oil, 33 and 66 per cent. cedar oil, 24 hours each. After remaining in cedar oil a few days, it was then carried through the grades of paraffin and cedar oil, 33 and 66 per cent. paraffin, to pure paraffin, melting point 54°, in which it was finally imbedded.

*Staining:* The buds were sectioned with a Minot-Zimmermann revolving microtome. In most cases they were cut 10 $\mu$ in thickness. The exceptions to this were the woody and hairy buds, the hickory, oak, basswood, birch, and alder. These buds were cut from 25 to 50 $\mu$ in thickness, depending upon the character of the bud. This greater thickness of the sections was not disadvantageous, since an outline study of the growing point, and not a cytological study, was desired. All sections were mounted serially. The usual method of staining with Delafield's hæmatoxylin was followed in all cases except one. The basswood sections are not well stained by this method because of the mucilaginous nature of the buds. The water used in the Delafield stain dissolves the mucilage which spreads over and obscures the tissue. A satisfactory stain was secured by using a solution of Bismarck brown in absolute alcohol. After the slides came from

the xylol, they were stained horizontally two or three minutes and washed in absolute alcohol. They were then cleared and mounted in the usual manner.

## GROSS STUDY OF BUDS

*Leaf content:* The observation that winter buds contain leaves is doubtless older than the science of botany. The final proposition to prove is, how many of the leaves which develop during the spring and summer actually exist in the bud at the beginning of winter. In a consideration of this question the number of leaves found in the terminal or upper axillary bud has been counted and compared with the number of nodes which developed in the same twig during the two or three preceding seasons. Such an enumeration, combined with a microscopical study of sections of buds fixed each month from November to May, 1905–6, and with field observations at the time of the unfolding of the leaves in the spring cannot fail to give results which must be regarded as conclusive.

Bailey (1898) says: "There are as many leaves packed away in the bud, as a rule, as there will be leaves on next year's shoot." He gives no citations of literature and presents no investigations on which to base this generalization. We are left in doubt whether an individual plant or different species of plants may show variation in this respect. All effort to find any published record more definite than this has been futile.

The whorls of leaves in the bud of *Acer platanoides* agree, as to number, with the number of nodes on the same twigs one, two, or three seasons back with the exception that, in some cases, the number of whorls is one more or one less than the number of nodes. Observations on a large number of primary branches together with the dissection of terminal buds show this variation in the number of nodes developed during different seasons. In fact, this tendency to variation is true of all trees and shrubs and is particularly noticeable in secondary branches. This discrepancy is easily explained by the fact that, practically under the same conditions, the number of nodes produced each season may vary slightly. Since the counts so nearly agree, it is, therefore, fair to assume that buds with four whorls of leaves will produce four nodes; those with three whorls will produce three nodes and so on. The number of nodes on the branches of each season is four

or three. The number of leaves in the bud is six or four plus a pair of papillae in position for the fourth or third whorl of leaves.

A study of the microscopic sections of the bud during the winter and spring shows no organization of new leaves. At the time of the swelling of the buds in early April, new growths appear at the meristematic point (FIGURE 33, *s.f.*). Field studies during the period of the unfolding of the leaves show with perfect clearness that these new growths are the first pairs of scales of the future terminal bud, the bud of the next season. The new scales, admirably protected by the encircling bases of the petioles of leaves, show exceedingly slow growth in comparison with the normal leaves, and an unmistakable differentiation into bud coverings.

Bud dissection of *Aesculus Hippocastanum* shows that the full number of leaves exists in the bud at the beginning of winter. In addition two pairs of tiny scales appear as papillae in the meristematic point (FIGURE 36, *s.f.*). As they develop in the spring, the long, pointed character, indicative of scales, becomes prominent. The number of whorls of leaves in the bud of the main branches is generally four, sometimes five. This corresponds with the usual number of nodes developed in the branches during previous seasons. It is an interesting observation that the number of nodes is always less where the terminal bud is a flower bud.

*Fagus americana* and *Fagus sylvatica* have their leaves well developed in the bud and contain the full number for the season, five to seven on the primary shoots, three to four on the secondary ones. These leaves are, on the whole, farther advanced in regard to form and structure than those found on any other buds examined.

The number of leaves in the buds of *Fraxinus americana*, *Liriodendron Tulipifera*, and *Hicoria ovata* is more or less readily determined with the aid of the dissecting microscope, and agrees in each case with the usual number of nodes on the twigs of previous seasons — three or four whorls in *Fraxinus*, seven to nine leaves in *Liriodendron*, and five to seven leaves in *Hicoria*. A comparative study of the microscopic sections of buds during the winter months and the observations in the field during the unfolding of the buds gives undoubted evidence that here, too, the full

number of leaves is packed away in the bud before the approach of winter.

Müller (1866–7) made an extensive study of *Fraxinus* from early spring to midsummer and found that the bud scales of the next season's terminal bud began a rapid development in April. The present study of *Fraxinus americana* confirms Müller's observations on this species, for, as will be seen by reference to FIGURES 34 and 35, no addition of leaves occurs during the winter months. The new additions, which take place after April 16, are the scales whose development has been traced by Müller.

*Philadelphus* enters upon the winter rest with the buds buried beneath the leaf scars. These buds were examined with difficulty, not only on account of their small size but because of the similarity between the outer coverings and the inner leaves. In the stained sections of the buds, these structures are differentiated and the leaves easily enumerated. Eight to ten whorls of true leaves are generally present and this is the usual number that unfolds. FIGURES 44 and 45 show median sections through a bud. The young whorls of leaves are closely appressed until the blades are quite well expanded. When the leaves are unfolded in May, there appear between the last two leaves two small, yellowish scale-like leaves which soon die away, evidently because the meristematic point itself ceases to function and thus terminates further growth at this point of the shoot.

There is little question that in the one conifer studied, *Picea excelsa*, the buds contain through the winter the complete number of rudimentary leaves. Küster (1899) says that in *Abies* and in *Pinus* the number of leaves in the bud is probably the same in the fall as during the time of unfolding. The present study would tend to confirm this view for *Picea*, since the earliest growth in the spring indicates a production of tiny scales at the growing point of the bud rather than the organization of more needle-like leaves.

The young leaves in the *Rhododendron* buds correspond frequently to the number of leaves and nodes present on shoots of the preceding season. The irregularity in branching renders the count difficult in growths of two successive seasons. The largest number of leaves counted in any bud is twelve; the largest number of nodes for previous years, fourteen. Because of the more or

less whorled arrangement about the meristematic point, an exact enumeration of leaves and papillae is impossible from a study of serial sections. There remains, then, an element of doubt as to the number of leaves and leaf fundaments actually contained in these buds.

In buds of *Syringa vulgaris* the inner bud scales so gradually emerge into leaves that it is impossible to differentiate between them. In fact what appear to be *bona fide* scales in the bud develop into normal leaves as the buds unfold. These scars are crowded more or less into the ring of true scale scars which in part become obliterated by the growth of the stem. Any enumeration of nodes, therefore, in the shoot of the preceding season is untrustworthy as a criterion for the number of leaves contained in the winter bud. The microscopic sections are more satisfactory in that they admit of a detailed and minute study of the vegetative point. From these slides it is evident that the vegetative point exhibits a variation in ability to produce new leaves in addition to those already existing in the bud. It is believed, from a study of the slides, that buds, which early in the spring develop buds in the axils of the uppermost leaves, do not make new leaves at the apex of the growing point, but that buds in which these axillary growths are absent early in the growing season, continue to form new leaves (FIGURES 12 and 13). A probable explanation lies in the assumption that the energy of growth is directed to the upper axillary buds rather than to the meristematic point of the bud. These cells soon cease to function and die, thus terminating the growth of the stem. It appears, then, that the leaf content of the bud of *Syringa vulgaris* may receive additions in the spring. These new leaves are few, one or two pairs at the most. They never fully develop but shrivel away when the meristematic point ceases to function.

There is evidence that, in the leaf buds of *Salix fragilis* and *Salix alba*, the leaves are not all organized at the beginning of winter. The nodes on primary shoots vary from seven to thirty-six. The leaves found in any bud of these shoots do not exceed thirteen in number plus one or two papillae; moreover, the very nature of the growing end, with its continued production of closely appressed leaves, seems to establish the conclusion that the leaf content is not complete in *Salix* at the beginning of winter.

In the buds of *Populus tremuloides* the leaves, from five to nine in number, are very small but comparatively well formed. The number of nodes found on the growth of a given season varies

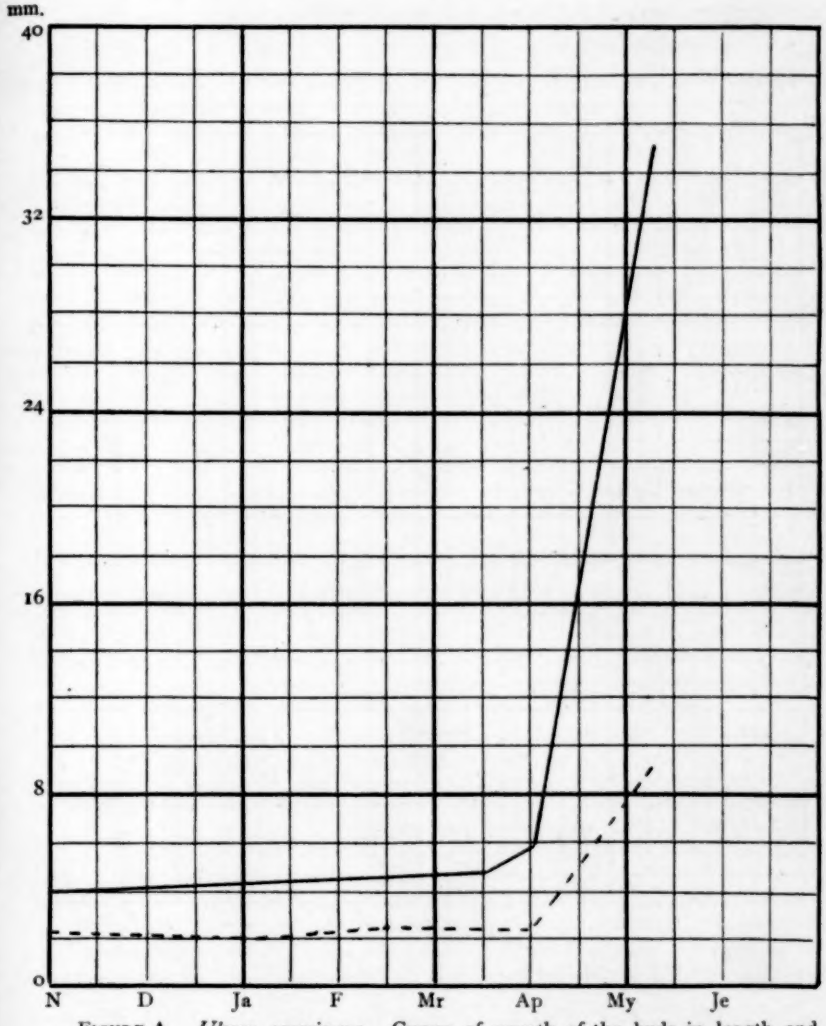


FIGURE A. *Ulmus americana.* Curves of growth of the buds in length and diameter.

from six to twelve. A growth of six nodes may follow one of six, ten, or twelve nodes and *vice versa.* This irregularity in the amount of growth occurs during different seasons or in the same

season. However, the sudden growth of the leaves, as though pushed out *en masse*, indicates that there are no new additions. The organization of a terminal bud and axillary buds as soon as the leaves unfold tends to substantiate this view.

In a consideration of the number of leaves in the buds of *Quercus alba* neither the gross nor the microscopic study was en-

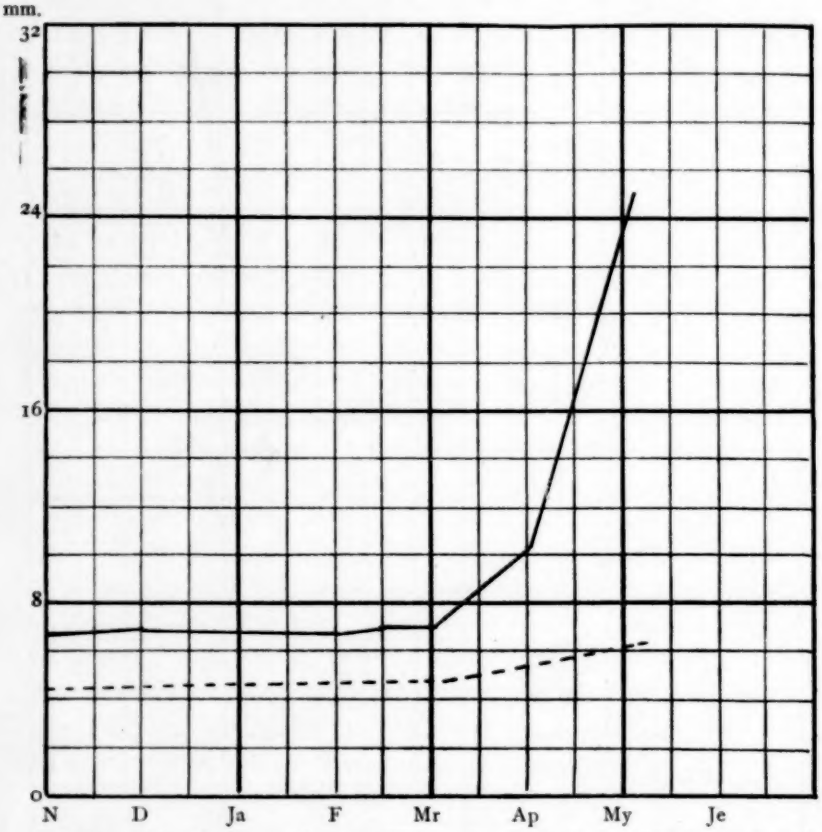


FIGURE B. *Syringa vulgaris*. Curves of growth of the buds in length and diameter.

tirely satisfactory. The leaves are not only exceedingly minute but they are densely covered with hairs which render sectioning difficult. Complete sections were too few to be of value in determining the actual number of leaves in the bud, but the unbroken vegetative points were more often secured and their study would indicate an approach, at least, to the full number of leaves. This

is especially true of buds which show in section numerous scale-like growths around the meristematic point. These scale-like growths appear, in the unfolding bud, to be the stipules of the whorl of leaves at the distal end of the young stem (FIGURE 48). Since the whorl is not a true one but is produced by a

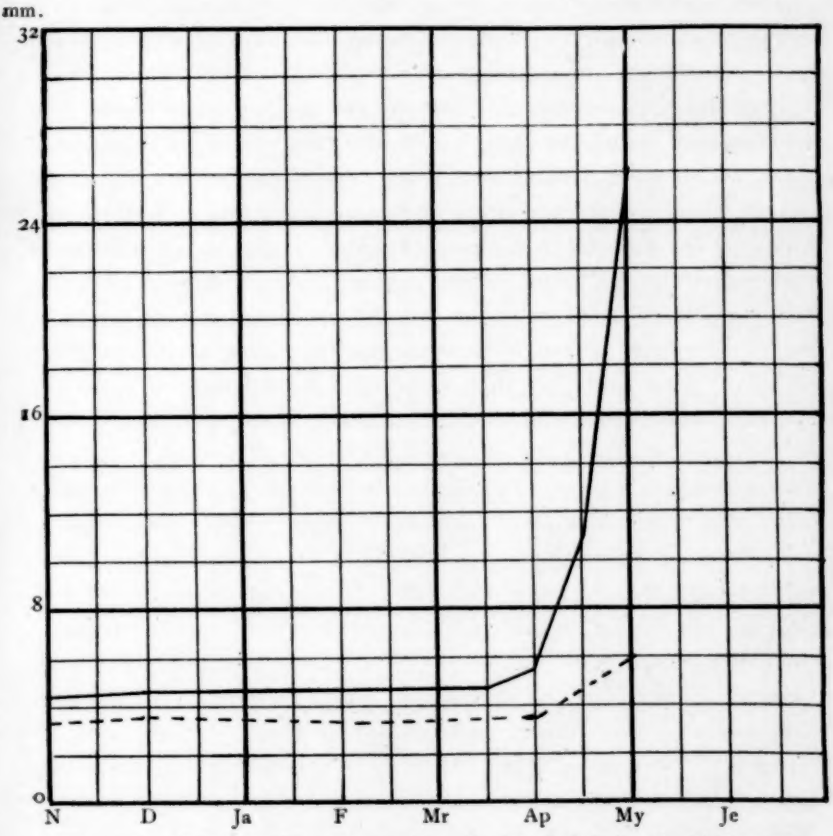


FIGURE C. *Quercus rubra.* Curves of growth of the buds in length and diameter.

shortening of the internodes in this part of the stem, the number of leaves at the beginning of winter for this species is still a matter of conjecture. Buds of *Quercus rubra* give stronger evidence of containing the complete number of leaves in that the leaves with the new terminal bud and the whorl of axillary buds are pushed out and developed simultaneously, as in *Populus*.

From evidence accumulated from November, 1905, to May 22,

1906, it is probable that in *Betula populifolia* the full number of leaves, five to eight in terms of nodes, does not exist in the bud during the winter. Two well-formed leaves are readily distinguished, but the rest of the bud is a gelatinous mass from which only one or two leaf-like bodies can be extricated. When the bud unfolds, the two well-formed leaves expand at once but the rest of the bud undergoes an exceedingly slow development, during which period it is probable that new additions of leaves are made.

In *Ulmus americana*, in *Tilia vulgaris*, and in *Alnus incana*, the leaf content cannot be determined with any reasonable degree of accuracy beyond the fact that a large proportion if not all of the leaves which unfold are present during the winter. The irregularity in the number of leaves and nodes renders a comparison of these quantities valueless. The answer to this question, as in the other doubtful cases, must be sought in a microscopic study of the development of the buds from the beginning of the swelling period in April and May to the end of leaf expansion in summer.

To summarize briefly, the full number of leaves which unfold in the spring exists in the winter buds of *Acer platanoides*, *Aesculus Hippocastanum*, *Fagus americana*, *Fagus sylvatica*, *Fraxinus americana*, *Liriodendron Tulipifera*, *Hicoria ovata*, *Philadelphus*, *Picea excelsa*, and *Populus tremuloides*. In *Syringa vulgaris* the full number may or may not exist. In the last case, the number probably developed in the spring does not exceed one or two pairs of leaves, which soon die when the meristematic point ceases to function. Although the number of leaves in the bud approaches the number characteristic of this species there still remains an element of doubt in the following: *Rhododendron maximum*, *Quercus alba*, *Ulmus americana*, *Tilia vulgaris*, and *Alnus incana*. New additions of leaves probably take place in *Betula populifolia*, in *Salix fragilis*, and in *Salix alba*.

*Measurements of buds :* It is a striking coincidence that those winters during which observations on the size of the bud have been carried on have been winters of extraordinary mildness.

Askenasy (1877), whose investigations on the growth of the flower buds of cherry extend over a period of three years, says: "It is an important fact that greater warmth in winter exercises but little influence on the growth of cherry buds. However, when

*Cornus mas* and *Forsythia viridissima* bloom in early January, as they often do, it is possible that the temperature of the fall and winter months has a higher significance for these species than for cherry."

Küster (1899) holds that those organs in which growth is demonstrable during an unusually mild winter cannot fail to show some advance in a normally cold one.

Buds which were measured during each month of the winter 1905–6, show no appreciable increase in length or in diameter, although the winter was one of unusual mildness, a winter in which the mean temperature, 27° F. for the coldest month, was

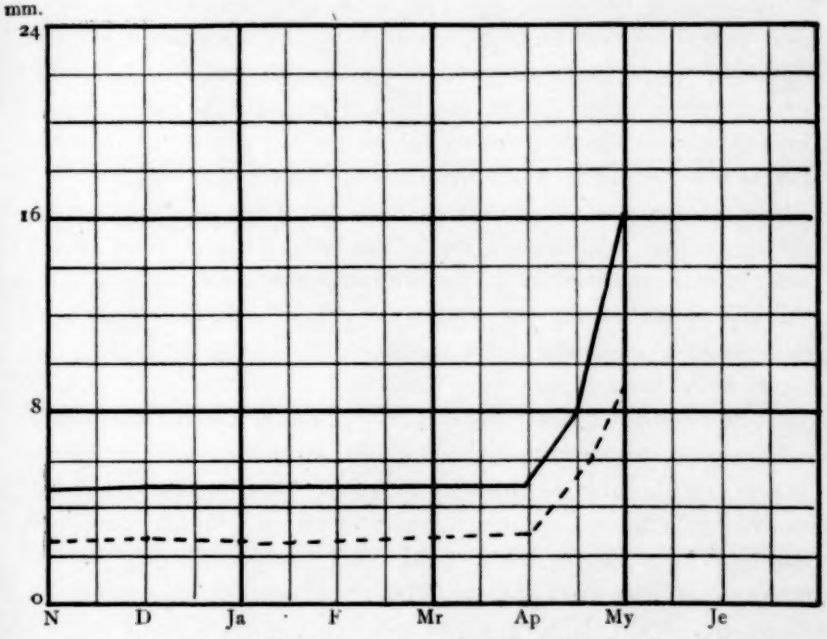


FIGURE D. *Quercus alba.* Curves of growth of the buds in length and diameter.

exceedingly high. The buds of the following species appeared absolutely dormant: *Fagus americana, Fagus sylvatica, Quercus alba, Quercus rubra, Tilia vulgaris, Tilia americana, Hicoria ovata, Hicoria mucrocarpa,* and *Fraxinus americana.* The flower buds of *Alnus incana, Ulmus americana, Betula populifolia, Populus tremuloides, Salix fragilis,* and *Salix alba* are more or less easily influenced by continuous high temperatures and consequently

show a variable development. The flower buds of *Ulmus* and the catkins of *Alnus* were noticeably larger in January. In some cases the catkins of *Salix* and *Populus* had pushed aside their scaly coverings as early as December, but such precocious growth in these two genera is confined to the flower buds of saplings and of immature growths. Favorable situations and exposure to warm sunshine are apparently factors which influence such premature development.

Sendtner (1851) observed that different parts of a plant show a different attitude toward the varied influences and growth stimulations affecting them during the winter months.

According to Schimper (1903), it has been proved experimentally that the flower buds, or reproductive organs, possess a lower optimum temperature for growth than is the case with leaf buds, or vegetative organs. This principle is apparent in nature, since, in each species observed during the winter of 1905–6, the true leaf bud is in all respects less active than the flower bud.

Wiegand (1905) mentions the fact that flower buds do not increase in size until late spring. Similarly, the leaf buds of the trees and shrubs studied in this investigation show practically no increase in size during the winter rest-period. At least their normal condition of apparent rest is not disturbed in so far as their external appearance is concerned.

The curves of growth (figures *A–J*) indicate a slight alternating increase and decrease during the winter, a gradual increase during March and a more rapid advance in April. The fluctuations of the curve during the winter months are a result of difficulties encountered in measuring the buds. The outer scales often dry out and many either loosen or fall away. This is clearly the case in *Hicoria*, *Picea*, and *Alnus*. The quantity and consistency of scale varnish varies also. But in spite of these difficulties a gradual continuous growth, if present, could not fail to be observed and recorded in a series of measurements which are made at regular and frequent intervals during the winter and spring. The curves of growth are therefore of value in illustrating the time and rapidity of swelling, as well as the variations which are exhibited by the different genera and species.

The time at which the different plants under investigation

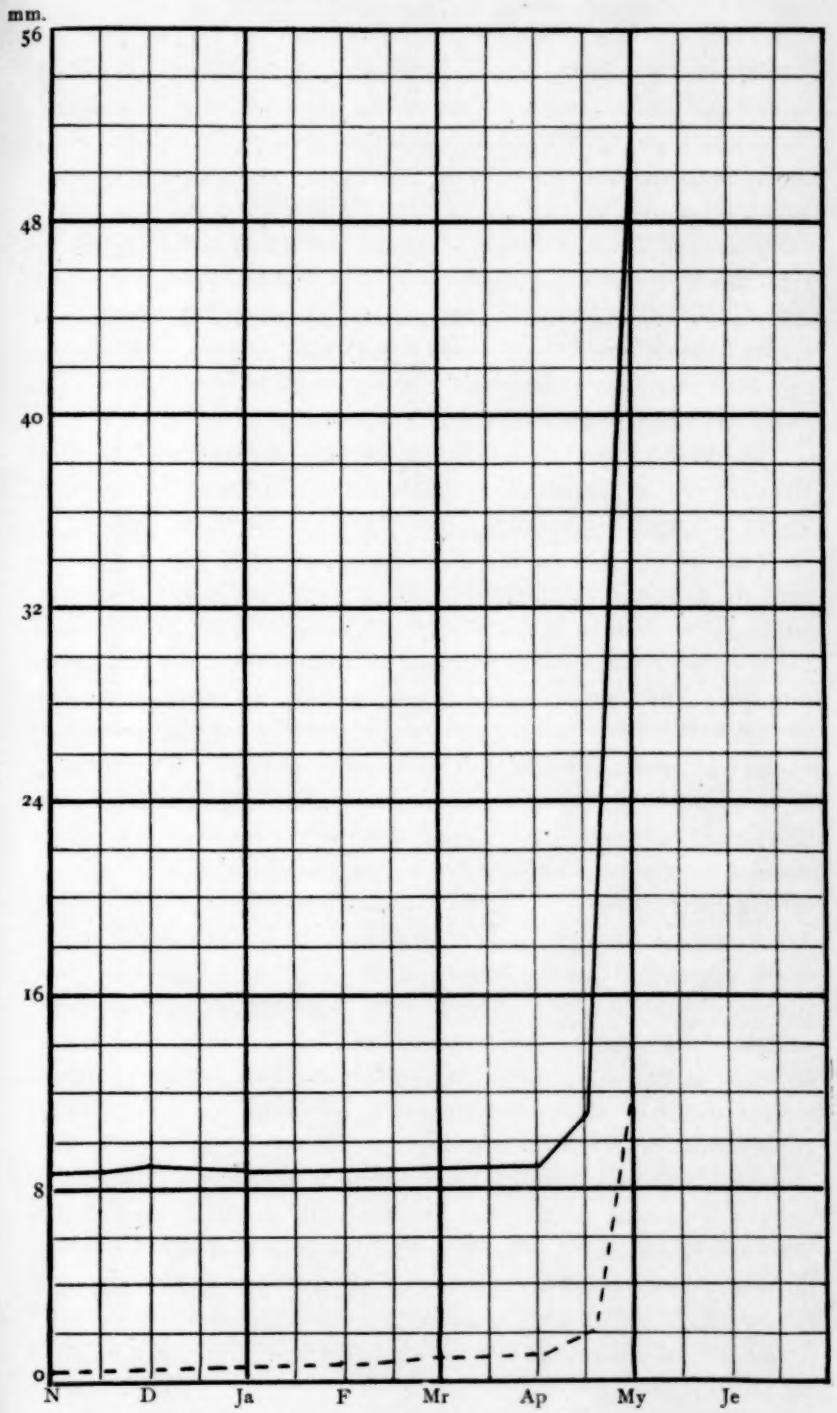


FIGURE E. *Hicoria ovata*. Curves of growth of the buds in length and diameter.

renew their growth in the spring varies considerably, as will be seen from the following curves. The curve of *Ulmus americana* illustrates a retardation in growth of about two weeks beyond that of *Syringa vulgaris* (FIGURES *A*, *B*). *Quercus rubra* and *Quercus alba* vary somewhat (FIGURES *C*, *D*). The buds of the two species of *Hicoria* differ not so much in time as in rapidity of development (FIGURES *E*, *F*). A greater delay in the swelling and unfolding of the buds occurs in *Tilia* and in *Betula* (FIGURES *G*, *H*). Buds of the two evergreens, *Rhododendron* and *Picea*, remain in a state of apparent rest until a later date than the buds of any other species that have been studied (FIGURES *I*, *J*).

Henslow (1901) remarks: "Buds are primarily the result of the lowering of temperature in autumn; for as soon as this rises above a certain degree they burst open and begin to grow." A comparison of the curve of temperature with the curves of growth indicates that temperature is not the only factor controlling the growth of buds. It will be seen that growth took place in March at a lower temperature than in the preceding winter months. Zero temperatures appear to have no effect on the size of the bud. Buds both with dry and with somewhat succulent scales were measured with the thermometer at 0°F. No difference in size could be detected as a result of these measurements. Wiegand (1905) records a similar observation for buds but finds a decided contraction in twigs due to the expulsion of air from the intercellular spaces.

As a rule, the first apparent evidence of growth in the bud is in the appearance, at the distal end, of small tufts lighter in color than the outer scales. These tufts were the elongating inner scales, which were soon followed by the leaves themselves. The increase in the diameter of the buds was proportionally much slower than the increase in length. A comparison of the field observations with the microscopic sections of the buds gives evidence of growth within the bud before it becomes visible externally. This was most clearly apparent in *Aesculus* (FIGURE 38).

Such observations regarding the period of rest and growth in buds may come to the eye of any careful and painstaking observer in the field. What takes place within the scales during this time is not so easily observed, yet one must admit that the unfolding

of the leaf is only the last phase of a long-continued development whose stages of progress can be little known without a microscopic study of the internal structures and tissues.

## MICROSCOPIC STUDY OF GROWTH

It is not the purpose of this investigation to trace the growth and development of leaves or leaf tissues from a purely embryological or cytological standpoint, but to consider changes in the size of cells already present, the addition of new cells or tissues, and the organization of new leaf fundaments.

A microscopic study of buds taken from the somewhat miscellaneous collection of trees and shrubs previously mentioned reveals a wide variability in the stage of development at which the

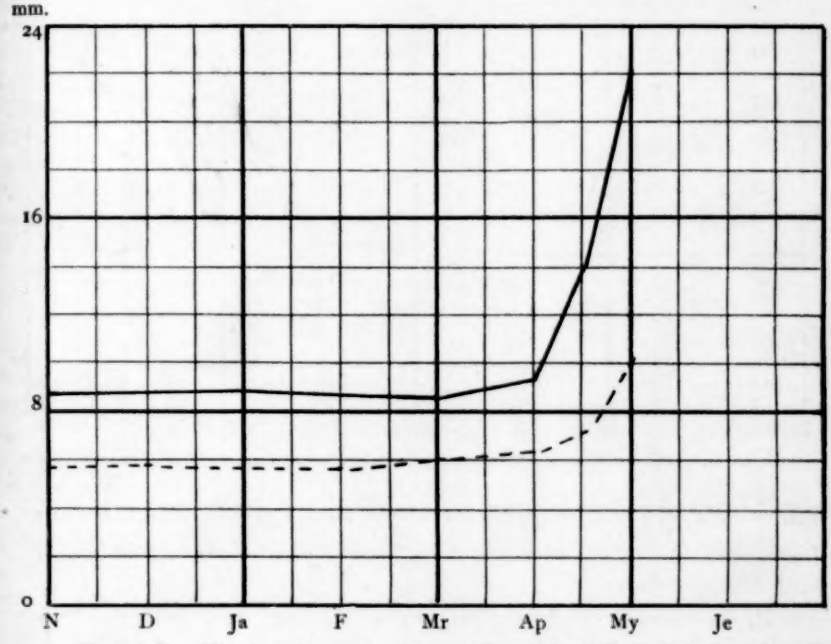


FIGURE F. *Hicoria microcarpa*. Curves of growth of the buds in length and diameter.

leaf buds enter the winter rest. At one extreme stand *Fagus americana* and *Fagus sylvatica* with all of their leaves well formed and the future terminal and axillary buds present and in an advanced stage of development. At the other extreme stand *Betula*

*populifolia*, *Salix fragilis*, and *Salix alba*, with an incomplete number of leaves and the axillary buds absent.

In *Fagus* neither the axis nor the axillary buds (FIGURE 15) show any change whatsoever until the April swelling which precedes the unfolding of the bud. Other cases in which the axillary buds are present in rudimentary form during the winter are *Fraxinus americana* (FIGURES 34 and 35), *Quercus alba* (FIGURES 46 and 47), *Ulmus americana* (FIGURES 17 and 18), *Alnus incana* (FIGURE 51), and *Syringa vulgaris* (FIGURE 8).

Mere areas of cells, which are rich in protoplasm and are stained more deeply than the surrounding tissue, occur in the leaf axils of *Liriodendron Tulipifera*, *Salix fragilis*, *Salix alba*, and *Acer platanoides*. No indications of axillary buds appear in the

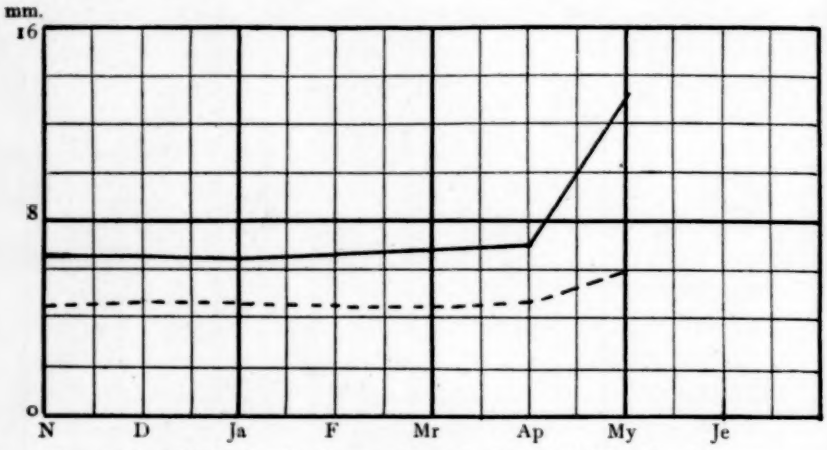


FIGURE G. *Tilia vulgaris*. Curves of growth of the buds in length and diameter.

following: *Aesculus Hippocastanum*, *Picea excelsa*, *Rhododendron maximum*, *Tilia vulgaris*, *Populus tremuloides*, *Betula populifolia*, and *Philadelphus*.

In the flower bud, according to Coulter and Chamberlain (1903), the spore-mother-cell stage seems to be the usual halting place at the beginning of the rest period.

In an embryological study of *Ulmus americana*, Shattuck (1905) found the cells within microsporangia in the mother-cell stage in the early part of February and assumed that they passed the winter in this stage.

Miss Ferguson (1904) found in *Pinus* that the archesporial tissue was not differentiated into the spore-mother-cells until April, thus disproving Coulter and Chamberlain's general statement, as well as their special one, in regard to the gymnosperms.

Chamberlain (1898) says: "The flower buds of *Salix* pass the winter in the pollen-mother-cell stage." This general statement for *Salix* is questioned since flower buds of *Salix fragilis* gathered in November did not follow this rule. In this case the cells of the anther appear to be homogeneous and show no differentiation of tissues.

It follows from these different observations that both leaf buds and flower buds enter the winter in various stages of develop-

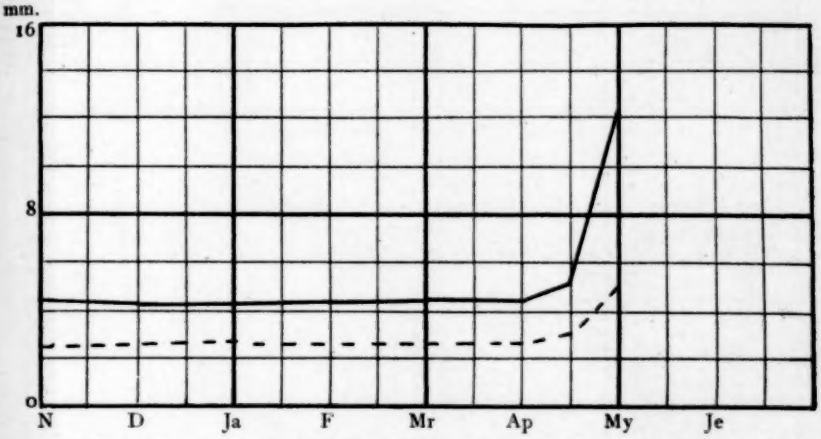


FIGURE H. *Betula populifolia.* Curves of growth of the buds in length and diameter.

ment. The exact point at which growth is suspended appears to be an inherited characteristic rather than one solely dependent upon climatic conditions.

We have seen that most buds, as a rule, do not increase appreciably in size during the winter months. The question that naturally arises is: Are these buds absolutely quiescent from November to February or are they undergoing changes which are not apparent externally?

Pfeffer (1903) claims that the influence of the continued cold of winter seems to have produced in the life of most plants in the colder zones a well marked period of rest. Strasburger (1903)

says: "It is not in reality an absolute rest; for although the outwardly visible processes of development and growth stand still, the internal vital processes, although retarded, never altogether cease."

The investigations of Miyaké (1902) demonstrate that in evergreen leaves "starch is formed by photosynthesis in winter, though feebly, and its translocation occurs in the same season."

According to Fischer (1891), who has made many important observations on the metabolic processes which occur within the

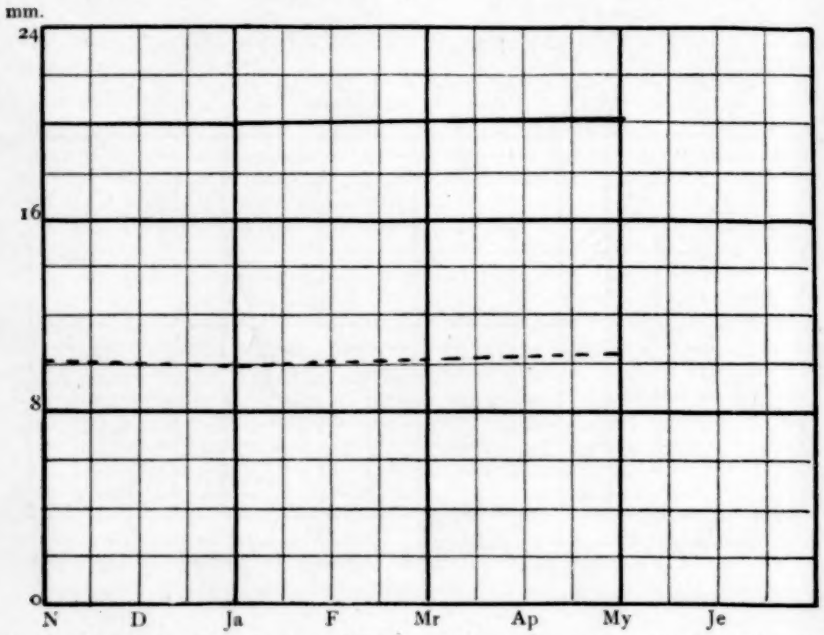


FIGURE I. *Rhododendron maximum.* Curves of growth of the buds in length and diameter.

tree during winter, various activities and movements of the reserve material take place in the interior of the tree long before any externally visible changes become apparent. The starch which is stored in the pith of the young shoot moves toward the buds and accumulates in the embryonic leaves and flowers from which hitherto it has been absent. It is a reserve material and just suffices for the first stages of growth preceding the swelling of the buds.

Hartig (1861) observed that the duration of time during which this transportation of reserve food takes place is about the same for all trees, two months in all, but that the beginning of this activity varies in different trees. Activity begins about the middle of February in *Acer*, and about the middle of March in *Quercus*.

Baranetzky (1873) suggests that the power of bleeding, which is so frequently observed in plants, is a direct expression of the internal changes which are repeated every year in hibernating trees.

Halsted (1890) observed in February small quantities of starch in the pistil and in the filaments of stamens, organs which in early winter do not contain this reserve food.

It is possible that as a result of these metabolic processes

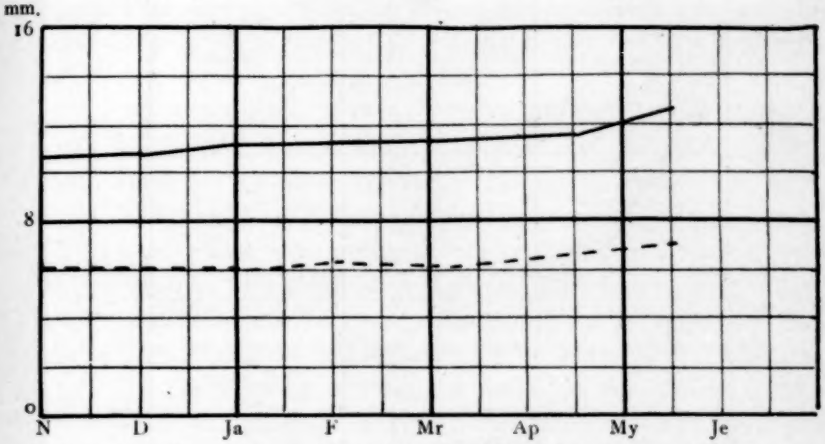


FIGURE J. *Picea excelsa*. Curves of growth of the buds in length and diameter.

growth is induced, although ever so slowly, and serves as a preparation for the sudden and rapid development of the young leaves and embryonic parts of the bud in the spring.

There are many difficulties necessarily in the way of determining absolutely any increase due to the stretching of cells in the leaf or in the leaf fundaments of the bud. In comparing buds for the different months of the rest period, slight variations in size and in stage of development must be expected, but irregularities in this respect are minimized by a comparison of a large number of similar buds.

The median sections of buds and meristematic points illustrated

in the present investigation were drawn after a comparative study of more than a thousand slides of serial sections representing over five hundred buds. It will be seen by reference to the plates that the leaf fundaments or lobes of homogeneous tissue, and the young leaves, which increase in size and in degree of development

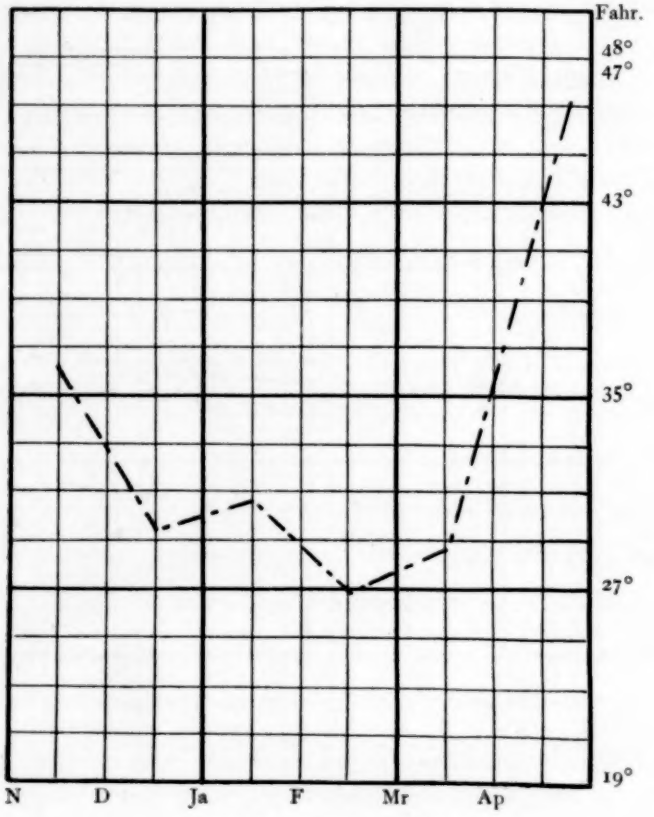


FIGURE K. Temperature curve.

toward the periphery of the bud, are arranged in acropetal order around the meristematic point (FIGURES 1, 8, 30).

In the species under investigation, growth of the leaf bud by addition of new tissue does not take place during November, December, or January. It seems apparent, however, that a stretching of cells occurs in many instances and manifests itself in the greater convexity of the meristematic point and its consequently

crowded condition (FIGURES 3, 4, 9, 21, 22). This stretching in the apical part of the meristematic region causes no change in the size or in the external appearance of the buds under investigation, although it becomes a measurable factor in the leaf buds of *Sambucus* and of *Prunus*, species which more readily respond to the continuous high temperatures of an unusually mild winter.

Küster says that during the warm winter of 1899 leaf buds of *Acer platanoides* showed not only a stretching of the cells but also an addition of new tissue in the axils of the upper leaves. These results must be seriously questioned, for his drawings of free-hand sections do not give the accuracy of detail which the microtome sections reveal. A careful search through many series of sections proves conclusively that what Küster called new tissues are the basal parts of the petioles which partially encircle the young axis of the bud (FIGURES 31 and 32).

All cells in the tissues of the winter buds are exceedingly small and closely packed together. A pronounced stretching of the tissue occurs in the following species during February: the inner scale fundaments of *Aesculus Hippocastanum* increase in length (FIGURE 38); the rudimentary leaves of *Syringa vulgaris* appear larger (FIGURE 10); the bud of *Philadelphus*, which in its dormant state is buried beneath the leaf scar, protrudes as a tiny bud through the rift in the upper portion of the scar.

The mean temperature for the month of March was exceptionally low for that month (FIGURE K), yet there are many evidences that growth occurred. *Liriodendron* and *Acer* show minute cushions of tissue which later develop into axillary buds (FIGURES 5 and 32). In *Alnus* the cushions of tissue increase slightly in size (FIGURE 51). A change in the color of the *Salix* buds, a change from a dull red to a more living one, gives evidence that the life processes are more active; their interior structure also reveals growth by the enlargement of parts at the growing tip (FIGURE 23), and in the more deeply staining tissue at the leaf axils. Buds of *Fraxinus* show no additional tissue but a general stretching of all parts. These buds which show a gradual but unmistakable advance in interior structure through February and March undergo rapid and vigorous growth in April when the leaf blades become more or less expanded and free.

In leaf buds which develop more slowly, as in *Quercus*, *Hicoria*, *Fagus*, *Populus*, and *Tilia*, there is little evidence of growth or stretching in the meristematic points or other local areas from November to March inclusive. It seems probable that growth entirely, or almost entirely, ceases for a time. A cytological and a physiological study of these parts as they occur during the winter is required to verify this conclusion.

Geleznoff (1851), a Russian investigator who studied the leaf buds of *Quercus* and *Betula* in their winter condition, says: "All buds make some advance in growth of new tissues and organs from December to February even at continued temperatures of 0° and less." It is possible this report of the organization of new parts at such temperatures is the result of incorrect observations of unlike buds, for plant physiologists hold that the growth and the construction of new organs at temperatures below 0° is impossible (Davenport, 1897).

In late March and early April the buds of *Quercus*, *Hicoria*, and *Fagus* begin a general swelling which becomes noticeable in a lengthening of the internodes and a more crowded condition of the meristematic point. *Betula*, *Populus*, and *Tilia* remain dormant for a longer time. Sections of the last two species indicate changes by the 16th of April in the general length of scale or leaf fundaments, and irregularities in the outline of the meristematic surface (FIGURES 26 and 29). Aside from the stretching of cells, the outline of the buds of *Betula* remains the same, but in the region of the leaf axils the tissue becomes more deeply staining than heretofore. On April 16 the leaf buds of *Picea* and *Rhododendron* appear as in the preceding months of the rest period (FIGURES 40–43). Observations on *Picea* in early May reveal an alteration in the papilla-like leaves which from now on assume rapidly their needle-shaped character. No change, up to this time, is visible in the leaf buds of *Rhododendron*.

## SUMMARY

In some species the full number of leaves that unfold in the spring exists at the beginning of winter. In other species, the majority of leaves are present at this time and additions occur at the time of unfolding. The terminal and axillary buds of the next

summer and autumn are in many cases well organized at the approach of winter.

The leaf buds of all deciduous and evergreen trees and shrubs investigated enter upon a winter resting period, the duration of which varies in the different plants.

The greater warmth of an unusually mild winter exercises but little influence on the growth of leaf buds. Flower buds respond more quickly to the influence of continuous high temperatures.

Of the species under investigation, some leaf buds show no change either in length or in diameter until February or March; others not until April or May.

In some cases growth may take place in February and March at lower temperatures than prevail during the preceding winter months.

Organization of additional tissues does not take place within the leaf buds during the winter but becomes apparent in March or April. A stretching of cells occurs in the meristematic region of some species as early as December and January, and manifests itself by a greater convexity of the meristematic surface. This change is microscopic and produces no change in the external appearance of the buds.

The first apparent evidence of growth is a swelling of the closely compacted tissues. With continuous high temperatures rapid and vigorous growth follows.

The leaf buds of the two evergreens investigated, *Picea* and *Rhododendron*, exhibit the longest rest period.

For valuable aid and supervision in carrying on this investigation most grateful acknowledgment is given to Dr. Margaret C. Ferguson, of Wellesley College.

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### Explanation of text figures and of plates 9-11

Figures *A–J* represent the curves of growth of the buds in length and in diameter. Figure *K* is the temperature curve. The continuous line indicates growth in length. The dotted line indicates growth in diameter. The dot and dash line shows the mean temperature. The numerals on the axis at the left of curves *A–J* represent the growth of the bud in millimeters. The numerals at the right of curve *K* indicate the mean temperatures, Fahrenheit. The bottom line represents the time during which measurements were made, the 25th of November, December, and January, the 10th and 25th of February, March, April, and May. As a rule, for each species, the measurements of ten buds are averaged for each curve. The curves end at the time of unfolding of the bud.

All figures in plates 9–11 were drawn with the aid of the Abbé camera lucida. A Zeiss microscope was used. All figures represent longitudinal sections. Figures 1 and 8 are magnified 10 times; all others are magnified 25 times. The abbreviations used in the explanation of plates are as follows:

Axis of incipient shoot, *a.*; axillary bud, *ax.b.*; base of petiole, *b.p.*; leaf, *l.*; leaf fundament, *l.f.*; petiole, *p.*; scaly covering, *s.c.*; scale fundament, *s.f.*; stipule, *st.*; terminal bud, *t.b.*; vegetative point, *v.p.*; vascular tissue, *v.t.*

PLATE 9

1–6. *Liriodendron Tulipifera*

1. Median longitudinal section of bud with two outer leaves removed. November.
2. Vegetative point during rest period. 29 D.
3, 4. Greater convexity of vegetative point and crowding of parts. 30 Ja, 28 F.
5. A general elongation of axis, of leaf, and of scale fundaments. 30 Mr.
6. Bud two weeks later than in preceding figure. Marked increase in size. 16 Ap.

7–14. *Syringa vulgaris*

7. Appearance of vegetative point during winter rest period. 25 N.
8. Median longitudinal section showing appearance of axis during winter. January.
9. Appearance of vegetative point in winter. 30 Ja.
10. Elongation of leaf fundaments. 28 F.
11. Stretching of parts and addition of upper axillary buds. 30 Mr.
12, 13. Two stages of vegetative point on April 16.
14. Axillary bud. 5 My.

15 and 16. *Fagus americana*

15. Typical structure of an axillary bud as found within the terminal bud during winter. November, March.
16. Same, showing increase in size. 16 Ap.

17–19. *Ulmus americana*

17. General appearance of vegetative point during winter. November.
18. Greater convexity of vegetative point. 30 Ja.
19. General growth of meristematic region. 16 Ap.

20–24. *Salix fragilis*

20. Winter condition of vegetative point. November, December.
21, 22. Greater convexity of vegetative point. 30 Ja, 28 F.
23. General stretching of meristematic region. 30 Mr.
24. Additional growth of new organs. 16 Ap.

25 and 26. *Tilia vulgaris*

25. Winter condition of vegetative point. February.
26. Greater breadth at vegetative point. March.

27. *Betula populifolia*

Appearance of apical part of bud in winter and spring. November, April.

28 and 29. *Populus tremuloides*

28. Winter condition of apical region. November, March.
29. General stretching and growth of meristematic region. 16 Ap.

PLATE 10.

30–33. *Acer platanoides*

30. Appearance during rest period. November, December.
31. General stretching of parts in meristematic region. January, February.
32. Appearance of scale fundament and upper axillary bud. 30 Mr.
33. General growth of parts and appearance of future terminal bud. 16 Ap.

34 and 35. *Fraxinus americana*

Appearances during rest period and early spring. November, March.

36–39. *Aesculus Hippocastanum*

36, 37. Appearances during rest period. November, January.

38. Elongation of scale fundaments. 28 F.

39. Broadening of apical region. 30 Mr.

PLATE 11

40 and 41. *Picea excelsa*

General dormant condition during winter and early spring. November, March.

42 and 43. *Rhododendron maximum*

Dormant condition during winter and spring. November, 16 Ap.

44 and 45. *Philadelphus*

44. Median longitudinal section of bud, showing winter condition. November, January.

45. Median longitudinal section of bud, showing stretching of parts. February, March.

46–48. *Quercus alba*

46. Axillary bud within the terminal bud at beginning of rest period. November.

47. Winter condition of vegetative point. December, March.

48. General stretching of parts. 16 Ap.

49–51. *Alnus incana*

49, 50. Appearances during winter rest period. November, February.

51. General growth in apical part of meristematic region. 30 Mr.

# The present treatment of monotypic genera of fungi *

C. L. Shear

In view of the approaching International Botanical Congress to be held in Brussels in 1910, at which it is proposed to provide rules for the nomenclature of the cellular cryptogams, and also in view of the impression which seems to prevail in some minds that the nomenclature of the fungi is in no great need of revision, it may not be inappropriate to call attention to one important phase of conditions as they now exist in mycological nomenclature, namely, the treatment of monotypic genera. Whatever views one may entertain in regard to the type method in general, as a basis of fixing genera and species, we do not anticipate there are many who would deny that genera originally based upon a single species should retain that species. In other words, one would rather expect a monotypic genus always to contain its monotype, however many other species might be added to it. The International Commission of Zoological Nomenclature has already adopted the type method of fixing genera. Their first rule is "a genus proposed with a single original species takes that species as type." In order to show the actual condition prevailing at present with reference to this particular phase of the question, the following cases are cited. These have been selected at random from the Pyrenomycetes and Fungi Imperfecti. Many more cases of the same kind could be found without difficulty.

*Coelosphaeria* Sacc. Myc. Ven. Spec. 115. 1873 was proposed as a substitute for *Nitschkia* Otth. 1869, which Saccardo regarded as a homonym of *Nitzschia* Hassall 1845. Only one species, *C. Fuckelii* (Nitsch.) Sacc., was included in the genus by Saccardo, *loc. cit.*, and this species happened to be the type of *Nitschkia*, the genus for which *Coelosphaeria* was substituted. Overlooking the fact that this same species was the type of *Cyathisphaeria* Dumort. 1822, note the use of the name *Coelosphaeria* by Ellis and Ever-

* Read beford Section G of the American Association for the Advancement of Science at the Baltimore Meeting, December 31, 1908.

hart, N. A. Pyren. 246, 1890. They use the name *Nitschkia* in connection with its original type, thus depriving Saccardo's *Coelosphaeria* of its monotype. The genus is then "emended" by Ellis and Everhart and the name *Coelosphaeria* applied to another group of species.

*Cryptosphaeria* Grev. Scot. Crypt. Fl. **1**: *pl. 13*. 1823. This, according to the original publication cited, was monotypic, *C. Taxi* (Sow.) Grev. being the only species described or mentioned at that time, although the next year, in Fl. Edin. 359. 1824, the author included many other species. In the original description he says "Sporules always? naked." In a footnote he says "they [the plants included in the genus] are always also characterized by having their spherules not enclosed in filiform tubes as in the true *Sphaeria*." Thus his description as well as his type excludes ascomycetous fungi. Now this monotype is found in Saccardo, Syll. Fung. **3**: 359 under *Diplodia* Fries 1834, to which genus it had been previously transferred by De Notaris, while *Cryptosphaeria* is cited by Saccardo as having been published at a later date than the original, Scot. Crypt. Fl. **4**: *pl. 201*. 1826, "*pro min. parte*," and is used to include fourteen species of pyrenomycetous fungi, only one of which was ever referred to the genus by Greville and that three years after the original publication of the genus.

*Cylindrosporium* Grev. Scot. Crypt. Fl. **1**: *pl. 27*. 1822. was based upon the single species *C. concentricum* Grev., which was described and illustrated in the place cited. Unger in 1833, Die Exantheme, 168, added two species to Greville's genus, but these were apparently not congeneric with Greville's species. Later, Berkeley and Broome examined Greville's type specimen and referred his species to the later genus *Gloeosporium* Desm. & Mont. Ann. Sci. Nat. Bot. III. **12**: 295. 1849, thus depriving Greville's genus of its monotype. *Cylindrosporium* was used for a time as a depository for miscellaneous species by Berkeley and others until Saccardo, Michelia **2**: 12, "emended" it and referred two species to it, one of his and one of Berkeley's. Later, in Syll. Fung. **3**: 737, he attributes the name to Unger "em. Sacc." Thus the monotype of Greville's genus has been transferred to a later genus and Greville's name used for another genus and attributed to a later author.

*Isothea* Fr. Summ. Veg. Scand. 421. 1849. A description of the genus is given and one species mentioned, *Sphaeria rhytismoides* Bab. with a citation of an illustration by Berkeley in Ann. & Mag. Nat. Hist. **6**: 361. 1841. This monotype is transferred by Saccardo to the more recent genus *Laestadia* Auers. 1869 as *L. rhytismoides* (Berk.) Sacc. Syll. Fung. **1**: 224, while *Isothea* is "emended" and restricted to a species, *I. Nyssae* B. & C. Grevillea **4**: 157. 1876, referred to it by Berkeley and Curtis many years later and entirely unknown to Fries and also unknown at present except for the original brief and imperfect description.

*Naemaspora* Willd. Fl. Berol. 414. 1787. This was published as a monotypic genus, being based on *Sphaeria bombarda* Batsch = *Bombardia fasciculata* Fr., which was later taken from *Naemaspora* and used as the monotype of *Bombardia* Fr. Summ. Veg. Scand. 1849. Authors have since attributed *Naemaspora* to various later writers, including Persoon, Ehrenberg, and Fries. Fries, Syst. Myc. 478, cites Ehrenberg; Lindau, in Engler and Prantl's Pflanzenfamilien, attributes the genus to Persoon; and Saccardo says "Pers. em." and spells the name *Naemospora*. All recent authors have applied the name to a group of Fungi Imperfecti having so far as known no particular relation to Willdenow's monotype.

*Septaria* Fr. Nov. Fl. Suec. **5**: 78. 1819. *S. Ulmi*, the monotype of Fries, now passes as *Phloeospora Ulmi* (Fr.) Wallr. The name was changed to *Septoria* by Fries because of a genus *Septaria* among animals (*cf.* Syst. Orb. Veg. 119. 1825). Saccardo cites Fr. Syst. Myc. **3**: 480. 1829 as the place of publication, where a description is given with mention of two species which had been added to the genus by Desmazières. In Summ. Veg. Scand. 426. 1849, Fries mentions the original monotype, *S. Ulmi*, first in a footnote as one of the type species.

*Phloeospora* Wallr. Fl. Crypt. Germ. **2**: 176. 1833 was based on two species, the first being *Septoria Ulmi* Fr. The monotype of *Septaria* having been taken from it and placed in the more recent genus *Phloeospora*, the name *Septoria* is applied to another group of species and "emend. Sacc." added, which was apparently regarded as sufficient explanation and justification of the act.

*Sphaeropsis* Lév. Dem. Voy. in Crim. **2**: 112. 1842 was based

upon a single species, *S. conica* Lév. n. sp., the specimens being apparently old, the spores were thought to be free. Later, it was found that the type was an ascogenous form and the species was placed by Cesati and De Notaris in their new genus *Amphisphaeria*, Schem. Sfer. Ital. 49. 1863, becoming *A. conica* (Lév.) Ces. & DeNot., which name has been adopted by Saccardo, Syll. Fung. 1: 719, while the name *Sphaeropsis* is applied to a great group of species of Fungi Imperfecti and the genus "emended."

It is perhaps unnecessary to cite further instances of this kind to illustrate the present practice of most mycologists. Saccardo has been referred to in connection with most of these cases, not because he furnishes the most notorious examples of this practice, but because his Sylloge Fungorum is a general work widely used and largely followed by mycologists at present. In many cases he simply followed the example of some preferred predecessor. Cases of the same sort can be found in Engler and Prantl's Pflanzenfamilien, Rabenhorst's Kryptogamen-flora and almost any general work on systematic mycology.

The present condition of mycological nomenclature, as indicated by the cases cited, has been brought about apparently in great part by several rather natural causes. One of the most important of these has been the want of accurate knowledge on the part of the earlier writers of the organisms with which they were dealing. With the poor microscopes available and the lack of time or inclination to use them, there is little wonder that important and essential microscopic characters of the smaller fungi were not recognized. Generic characters and descriptions were therefore generally based upon superficial examinations of specimens with the naked eye or a hasty and insufficient study with a magnifier or microscope. As a consequence, the descriptions given were usually very imperfect or erroneous. As the older mycologists seem to have tried to interpret genera by descriptions or concepts instead of appealing directly to the actual organism which the original author used, this may account in part, perhaps, for the neglect of types. All subsequent writers, as well as the author of a genus, appear to have felt perfectly free to take one or all the species from a genus at any time or to modify or amend its description according to their conception of it. This

attitude towards the subject also appears to account in part at least for the practice of citing different authors for the same genus or different works of an author as the place of publication. Writers seem to have felt at perfect liberty to attribute a genus to the person whose idea of its limits most nearly accorded with theirs, without particular reference to its treatment or the species included in it by its original author. The place of publication cited for a genus seems either to have been selected upon the same basis or else chosen because it happened to be the most convenient or accessible work. Thus it happens that the ordinary citations for the publication of fungus genera do not, in the majority of cases perhaps, refer to the first or original description or author of the genus. Blind following of authority has also contributed its share towards bringing about the present deplorable condition.

Without adopting some plan of permanently fixing generic names to some particular species, it is difficult to understand how any degree of stability or uniformity can be attained in the use of names.

WASHINGTON, D. C.

## New species of fungi

CHARLES HORTON PECK

### Clitopilus Davisii

Pileus thin, convex, becoming nearly plane, glabrous, creamy white or buff, flesh white, odor and taste farinaceous; lamellae narrow, thin, close, adnate or slightly decurrent, white becoming flesh-colored; stem slender, equal or slightly tapering upward, solid or stuffed, subbulbous, white or whitish, shining, becoming brown or brownish with age, often with a white mycelium at the base; spores subglobose, angular, uninucleate, 8–10 $\mu$ broad.

Pileus 2–3 cm. broad; stem 4–7 cm. long, 2–6 mm. thick.

Gregarious; in dry, gravelly soil. Stow, Massachusetts. September. Simon Davis. The pileus is said to be umbonate in the fresh state, but in the dried specimens it is subumbilicate.

Pileus tenuis, convexus, deinde subplanus, glaber, flavus, carne albida, odore saporeque farinaceis; lamellae angustae, tenues, confertae, adnatae vel leviter decurrentes, albae, deinde incarnatae; stipes gracilis, aequalis vel sursum leviter attenuatus, solidus farctusve, subbulbosus, nitidus, albidus, in maturitate brunnescens, saepe basi mycelio albo; sporae subglobosae, angulares, uninucleatae, 8–10 $\mu$ latae.

Pileus 2–3 cm. latus; stipes 4–7 cm. longus, 2–6 mm. crassus.

### Eccilia flavida

Pileus thin, convex, glabrous, umbilicate, pale yellow, obscurely striate when dry; lamellae thin, somewhat close, decurrent; stem slender, glabrous, hollow, colored like the pileus or a little paler, commonly with a white mycelium at the base; spores subglobose, angular, 8–12 $\mu$ × 6–8 $\mu$.

Pileus 2–2.5 cm. broad; stem 2.5–3.5 cm. long, 1.5–2 mm. thick.

Stow, Massachusetts. September. George E. Morris. In the dried specimens the umbilicus has a whitish color and the lamellae are colored like the pileus.

Pileus tenuis, convexus, glaber, umbilicatus, flavidus, siccatus obscure striatus; lamellae tenues, subconfertae, decurrentes; stipes gracilis, glaber, fistulosus, in colore pileo similis, saepe basi mycelio albo; sporae subglobosae, angulares, 8–12 $\mu$ × 6–8 $\mu$.

Pileus 2–2.5 cm. latus; stipes 2.5–3.5 cm. longus, 1.5–2 mm. crassus.

### Boletus Morrisii

Pileus fleshy, convex, dry, glabrous, smoky brown with a yellow margin or yellow and red with brown spots, the margin surpassing the tubules, flesh pale yellow; tubules at first short, minute, bright yellow, then elongated, convex in mass, orange-brown, rounded behind and depressed about the stem or free, the mouths larger, subrotund; stem equal or slightly thickened toward the base, solid, punctate with minute reddish dots, yellowish externally, pale yellow within and sometimes streaked with reddish brown; spores oblong fusiform, 10–15 $\mu$ × 4–5 $\mu$.

Pileus 2.5–8 cm. broad; stem 5–8 cm. long, 8–12 mm. thick.

In sandy soil under scrub oaks. Ellis, Massachusetts. August. G. E. Morris. The species belongs to the section *Edules*, and is well marked by its dotted stem.

Pileus carneus, convexus, siccus, glaber, fumoso-brunneus, in margine lutescens, margine tubulos excedente, carne flavida; tubuli primo brevissimi, minuti, aurei, deinde elongati, convexi, circum stipitem depressi vel liberi, subrotundi, aurantiaco-brunnei; stipes aequalis vel leviter basi incrassatus, solidus, punctis minutis rufescentibus asperatus, extus lutescens, intus flavidus vel colore rufo-brunneo tinctus; sporae oblongo-fusiformes, 12–18 $\mu$ × 4–5 $\mu$.

Pileus 2.5–8 cm. latus; stipes 5–8 cm. longus, 8–12 mm. crassus.

### Herpotrichia rhodospiloides

Perithecia gregarious, globose, seated on or involved in an effused thin black tomentum, subglabrous and dull reddish brown or grayish at the apex, sometimes entirely black; ostiola obscurely lacerated; asci clavate or subcylindric, 60–100 $\mu$ long, 10–12 $\mu$ broad; spores crowded or subdistichous, oblong or subfusiform, straight or slightly curved, uniseptate with one or two nuclei in each cell, hyaline, becoming slightly colored with age, 16–20 $\mu$ × 6–8 $\mu$.

On decorticated wood of cottonwood, *Populus deltoides* Marsh. Batesville, Arkansas. October. Elam Bartholomew.

The fungus forms thin somewhat interrupted black patches on the surface of the wood. The tomentum is composed of slender black flexuous filaments. The species is closely allied to *Herpotrichia rhodospila* (B. & C.) Sacc. but differs from it in the paler color of the apex of the perithecium and in having uniseptate

spores. The subiculum also is tomentose, not crustaceous. The perithecia are sometimes entirely black and almost wholly glabrous.

Perithecia gregaria, globosa, tomento effuso atro insidentia, ad apicem subglabra rufo-brunneaque vel grisea, aliquando omnino atra, ostiolis obscure laceratis; asci clavati subcylindraceive, 60–100 $\mu$ longi, 10–12 $\mu$ lati; sporae confertae subdistichaeve, oblongae, subfusiformes, rectae vel subcurvatae, uniseptatae, hyalinae, in maturitate flavescentes, 16–20 $\mu$ longae, 6–8 $\mu$ latae; cellula quaque 1–2-septata.

### Botrytis uredinicola

Tufts 1–2 mm. broad, hypophyllous, soft, snowy white; hyphae rather short, sparingly branched, septate, branches very short; spores globose, hyaline, 8–10 $\mu$ in diameter.

Parasitic on sori of some uredinous fungus inhabiting leaves of tall smooth panic grass, *Panicum virgatum* L. Stockton, Kansas. July. E. Bartholomew. Related to *Botrytis pilulifera* Sacc. but differing from it in its habitat and in its much smaller spores.

Caespites 1–2 mm. lati, hypophylli, molles, nivei; hyphae breviusculae, sparse ramosae, septatae, ramis brevissimis; sporae globosae, hyalinae, 8–10 $\mu$ latae.

### Gyroceras divergens

Spots on the upper surface of the leaf grayish with a faint purplish tinge, on the lower surface purplish brown, more or less confluent; hyphae hypophyllous, the sterile creeping, branched, often short, hyaline or pallid, the fertile suberect, multiseptate, variable in length and diameter, 20–80 $\mu$ × 6–10 $\mu$, forming brown tomentose patches, the cells 4–8 $\mu$ long, 6–10 $\mu$ broad, sometimes a few of them with a longitudinal septum.

On living leaves of sugarberry, *Celtis occidentalis* L. Batesville, Arkansas. October. E. Bartholomew.

This species differs from *Gyroceras Celtidis* (Biv.) M. & C., an inhabitant of *Celtis australis*, in the color of the spots and in its chains of spores, which are shorter, broader, and erect, not incurved or involute at the apex, and in sometimes having a few of the articulations longitudinally divided. In this character the species diverges from the typical character of the genus. The number of septa in a spore chain may vary from 3 to 15, but in *G. Celtidis* they may exceed 20. In our fungus the apical cells or spores are sometimes broader than the basal ones, thereby giving

a subclavate shape to the whole chain. An occasional constriction is seen in some chains, which is suggestive of *Septonema*.

Maculae foliorum facie superiore griseae, facie inferiore purpureo-brunneae, saepe confluentes; hyphae hypophyllae, steriles repentes, ramosae, vulgo breves, hyalinae pallidaeve, fertiles suberectae, multiseptatae, 20–80 $\mu$ × 6–10 $\mu$, areas tomentosas brunneas formantes, loculis 4–8 $\mu$ longis, 6–10 $\mu$ latis, paucis septo longitudinali aliquando divisis.

**Cercospora brunnea**

Tufts hypophyllous, minute, densely effused on angular, sometimes confluent brownish spots, which are 2–5 mm. broad; hyphae crowded, flexuous, sparsely septate, brown, 60–100 $\mu$ × 5–6 $\mu$; spores cylindric or subclavate, often curved, 1–3-septate, subhyaline, 40–60 $\mu$ long, 5–6 $\mu$ broad.

On leaves of tall white lettuce, *Prenanthes altissima* L. Rogers, Arkansas. September. E. Bartholomew. This differs from *C. Prenanthis* E. &. K. in its brown hyphae and septate spores.

Caespites hypophylli, minuti, dense effusi, maculas angulares, saepe confluentes, brunnescentes, occupantes, 2–5 mm. latas; hyphae confertae, flexuosae, 1–3-septatae, brunneae, 60–100 $\mu$ × 5–6 $\mu$; sporae cylindraceae vel subclavatae, saepe curvatae, subhyalinae, 40–60 $\mu$ longae, 5–6 $\mu$ latae.

**Cercospora biformis**

Spots brown, angular, limited by the veinlets of the leaf, sometimes confluent; hyphae hypophyllous, flexuous, septate, brown, 30–150 $\mu$ long, 4–6 $\mu$ thick; spores of two kinds, one nearly cylindric, hyaline, obtuse at each end, commonly 3- or 4-septate, 40–100 $\mu$ long, 4–6 $\mu$ broad, the other narrowed above into a long slender prolongation, hyaline, 6–12-septate, about 6 $\mu$ broad in the widest part, 3 $\mu$ in the narrowest part.

On living or languishing leaves of passion flower, *Passiflora incarnata* L. Batesville, Arkansas. October. E. Bartholomew.

This species differs from *Cercospora fuscovirens* Sacc., an inhabitant of the yellow passion flower, *Passiflora lutea* L., in producing yellow spots on the leaves and in the dimorphic character of the spores. From *Cercospora truncatella* Atk., which also inhabits leaves of *P. incarnata*, it may be separated by its angular spots with no brown margin, by its hypophyllous hyphae, and by the two-formed spores.

Maculae brunneae, angulares, folii venulis limitatae, aliquando confluentes; hyphae hypophyllae, flexuosae, septatae, 30–150 $\mu$ longae, 4–6 $\mu$ latae, brunneae; sporae biformes, una subcylindracea hyalina utrinque obtusa, vulgo 3–4-septata, 40–100 $\mu \times$ 4–6 $\mu$, altera in partem gracilem longam sursum extenuata, 6–12-septata, hyalina, 5–6 $\mu$ ad partem latissimam, 3–4 $\mu$ ad partem angustissimam crassa.

**Fusarium juglandinum**

Tufts minute, superficial, floccose, subconfluent or effused, whitish becoming slightly tinged with pink; hyphae short, slender, dense, hyaline; spores fusiform, curved, pointed at each end, 3–7-septate, commonly 4–6-septate, 30–60 $\mu$ long, 6–8 $\mu$ broad.

Dead shoots of black walnut, *Juglans nigra* L. Stockton, Kansas. July. E. Bartholomew. The species belongs to the subgenus *Fusisporium* as arranged in Saccardo's Sylloge, Vol. IV.

Caespites minuti, superficiales, floccosi, subconfluentes vel effusi, albidi, deinde colore rosaceo leviter tincti; hyphae breves, graciles, densae, hyalinae; sporae fusiformes, curvatae, utrinque acuminatae, 3–7-septatae, vulgo 4–6-septatae, 30–60 $\mu$ longae, 6–8 $\mu$ latae.

**Fusarium Bartholomaei**

Sporodochium compact, subglobose oblong or pulvinate, arranged in series, whitish, a long time covered by the elevated epidermis; sporophores slender, erect, straight, crowded, 40–60 $\mu$ long, 1–2 $\mu$ broad; spores slender, curved, 5–6-nucleate, continuous, hyaline, terminating at each end in a very thin bristle-like point, 15–25 $\mu$ long, 1–2 $\mu$ broad, the bristle-like point 10–12 $\mu$ long.

Lower surface of leaves of Indian grass, *Sorghastrum nutans* (L.) Nash. Stockton, Kansas. September. E. Bartholomew. The species belongs to the subgenus *Fusamen*. It is well marked by the bristle-pointed spores, and is peculiar in having its receptacles mostly arranged in lines and covered for a long time by the firm epidermis of the host plant.

Sporodochia compacta, subglobosa, oblonga pulvinatave, in series digesta, albida, epidermide elevata diu tecta; sporophori graciles, recti, conferti, 40–60 $\mu$ longi, 1–2 $\mu$ lati; sporae graciles, curvatae, 5–6-nucleatae, continuae, hyalinae, in setula tenuissima utrinque terminantes, 15–25 $\mu \times$ 1–2 $\mu$, setulae 10–12 $\mu$ longae.

GEOLOGICAL HALL,
ALBANY, NEW YORK.

## Additions to the flora of Peninsular Florida

### I. NATIVE SPECIES

JOHN K. SMALL

The species enumerated below are for the most part additions to the hitherto known flora of the United States. They are all new to the mainland and only five of them were heretofore known as members of the flora of the United States from specimens collected on the Florida Keys.

With one or two exceptions, these additions were brought to notice by exploration carried on by the New York Botanical Garden, and the type specimens of the species here described for the first time are preserved in its herbarium.

**Thysanella robusta** sp. nov.

Plants mainly 6–9 dm. tall, often somewhat spreading, much stouter than those of *T. fimbriata:* leaves 3–6 cm. long, ascending; blades linear, acute, striate-nerved; ocreae imbricate on the lower part of the stem, mostly separated above, copiously fringed: racemes mainly 4–7 cm. long, 8–10 mm. thick, the ocrealae closely imbricate, each terminating in an elongate pale tip: calyx white, often becoming pink; the outer sepals entire or irregularly cleft, the inner ones becoming 3.5 mm. long: filaments about 4 mm. long: achenes fully 2 mm. long and fully 1.5 mm. wide, long-beaked.

A species hitherto confused with *Thysanella fimbriata.* It differs from that species by its much greater size, the larger sepals and achenes. Specimens collected at Braidentown, Florida, August 28, 1901 (*Tracy 7638*), may constitute the type.

Other recently collected specimens belonging to this species are: Jensen, March 25, 1897, *Curtiss 5837.* Dade County, November & December, 1903, *Eaton 776.*

**Warea Carteri** sp. nov.

Annual, glabrous, bright green: stems erect, 4–15 dm. tall, simple or widely branched above, mostly purple-tinged below, terete: leaves alternate; blades linear or sometimes cuneate, espe-

cially on the lower part of the stem, 1.5–3.5 cm. long, abruptly pointed or mucronate, often slightly veiny: racemes many-flowered, the rachis becoming 12–20 mm. long: pedicels becoming 9–12 mm. long: sepals 4.5–5.5 mm. long, nearly linear to somewhat spatulate: petals white or nearly so, 6–8 mm. long, the claws prominently sharp-toothed, the blades orbicular to reniform, undulate: stamens 7–8 mm. long, the anthers about $\frac{1}{3}$ as long as the filaments: ovary-body about as long as the stipe: pod-bodies 5–6 mm. long, curved, terminating the stipe, which becomes 6–7 mm. long.

Named for Mr. J. J. Carter, of Pleasant Grove, Pennsylvania, who has been associated with the writer in the exploration of South Florida.

This, apparently the most common species of *Warea*, occurs in great abundance, especially in southern peninsular Florida. Specimens belonging here have hitherto been confused with *Warea cuneifolia* (Muhl.) Nutt. *Warea Carteri* differs from *W. cuneifolia* in its narrower sepals, white corolla, suborbicular or reniform petal-blades, longer-stipitate ovary, shorter pedicels, longer pod-body and shorter mature stipe. The type specimens were collected in pinelands between Cutler and Black Point, Florida, November, 1903 (*Small & Carter 831*). Other specimens belonging here are as follows:

Miami, November, 1878, *Garber 26*; October and November, 1903, *Small & Carter 511*. Indian River region, September, *Curtiss 171*.

**Cracca corallicola** sp. nov.

Perennial, densely pale-hairy all over, the branches, peduncles and petioles short-hirsute: stem erect, 4–19 dm. tall, densely branched, the branches decidedly zigzag, rather rigid: leaves numerous, 4–11 cm. long; leaflets 11–15, 9–31 mm. long, the blades linear to linear-oblong, mucronate, prominently ribbed, copiously pubescent: stipules quite persistent, 1–3 mm. long: racemes several-flowered, borne on short peduncles: pedicels stout, becoming 2–3.5 mm. long: calyx permanently hirsute; tube broadly campanulate; lobes subulate above the broader bases, the lower ones nearly as long as the tube: corolla pinkish or purplish; standard 7–11 mm. long; blades orbicular or obovate-orbiculate; wings 6–7 mm. long; keel shorter than the wing-petals: pods 3.5–4.5 cm. long, about 3 mm. wide, finely pubescent: seeds fully 3 mm. long.

This species differs from *Cracca cinerea* L. by its pubescence, the shape of the blades of the leaflets, the smaller corolla and the short calyx-lobes. The type specimens were collected in pinelands between Cocoanut Grove and Cutler, November, 1904 (*Small 2112*).

SWIETENIA MAHAGONI Jacq.

As a member of the flora of the United States, the mahogany has heretofore been confined to the Florida keys. Its range may now be extended to the mainland, where it was found growing on the Everglade Keys in the large hammock south of Miami in November, 1904 (*Small 2272*).

CAPERONIA CASTANAEFOLIA (L.) St. Hil.

This West Indian plant was discovered growing on Long Key (Everglades) in January, 1909 (*Small & Carter 2832*).

CHAMAESYCE BLODGETTII (Engelm.) Small

Hitherto this species has been known only from the lower Florida keys and the Bahamas. Several years ago it was discovered on the mainland, growing plentifully in open hammocks back of Black Point below the settlement of Cutler (*Small & Carter 823*).

COLUBRINA RECLINATA (L'Her.) Brongn.

The tree was found on the Everglade Keys, growing in hammocks southwest of the settlement of Perrine in November, 1904 (*Small 2249a*).

PASSIFLORA PALLENS Poepp.

Specimens matching C. Wright's Cuban specimens numbered 2599 were collected from plants growing on the edges of several hammocks in the homestead country southwest of Cutler. The species was first discovered in Florida near Camp Longview by Mr. P. Wilson and the writer (*no. 1740*) and later by the writer on the Caldwell and adjoining homesteads (*no. 2143, 2557 & 2559*). The plants are remarkable on account of their large stipules, and in this respect they resemble those of the South American *Passiflora stipulata* Aubl.

SOLANUM BLODGETTII Chapm.

Previous to the year 1904 this species was known only from Key West. During the past few years it has been collected both

on the mainland of Florida and on the Bahamas. The following citations represent specimens from peninsular Florida. They are all from the Everglade Keys and vicinity.

Everglades near Camp Jackson, *Britton 237*. Hammocks, Long Key, *Small & Wilson 1678*. Everglades west of Camp Jackson, *Small & Wilson 1962*. Everglades between Homestead and Cross Key, *Small & Carter 2675*.

BOURRERIA VIRGATA (Sw.) G. Don

The shrub or small tree was recently discovered growing on an outlying Everglade Key situated about eight miles below the settlement of Cutler (*Small & Carter 2818*).

**Goniostachyum citrosum** sp. nov.

A straggling or reclining shrub with elongate and irregularly branched stems, the bark pale-gray or whitish, the branches strigillose: leaves opposite; blades lanceolate to elliptic-lanceolate, 2.5–6 cm. long, acuminate, shallowly serrate, pubescent on both sides, pale beneath, dark green above, narrowed to petiole-like bases: peduncles solitary in the axils, 5–16 mm. long, strigillose: spikes depressed, 4–6 mm. long; bracts ovate, acute or acuminate, the outer ones 4–5 mm. long: calyx about 1 mm. long; lobes broadly triangular, much shorter than the tube: corolla white, about 4.5 mm. long, minutely pubescent; tube swollen above the middle; limb about 3 mm. broad: nutlets 1.5 mm. long.

This species differs from *Goniostachyum graveolens* by its strigillose foliage, its sparingly and shallowly serrate acuminate leaf-blades and its short spikes. The type specimens were collected in the hammocks near the Silver Palm Schoolhouse southwest of Perrine, November, 1904 (*Small 2142*). Collected in 1906 in the same region (*Small & Carter 2680*).

This plant was first collected in Mexico many years ago; but these specimens were referred to *Lantana canescens* H. B. K., a species originally from northern South America. The species was discovered in Cuba the same year that it was first found in Florida. Its geographical distribution seems to be the same as that of *Alvaradoa amorphoides* Liebm., with which it is associated in the hammocks in Florida.

**Phyla stoechadifolia** (L.) comb. nov.

*Verbena stoechadifolia* L. Sp. Pl. 19. 1753.

*Lippia stoechadifolia* H. B. K. Nov. Sp. & Gen. Pl. **2**: 265. 1817.

Recent exploration on Long Key (Everglades) brought this verbenaceous plant to light as a member of the flora of the United States (*Small & Carter 2863*). On certain portions of the largest island of the group the plants grew in great abundance.

LANTANA OVATIFOLIA Britton

This species described from plants collected on the Bahamas is common in southern peninsular Florida. The collections cited below belong to this species:

Punta Rassa, *Hitchcock 268*.
Bull Key, opposite Lemon City, *Small & Carter 618*.
Ft. Lauderdale, *Small & Wilson 1747*.
Between Homestead and Camp Jackson, *Small & Wilson 1877*.
Beach opposite Miami, *Small 2101*.
Palm Beach, *Small 2134*.

GERARDIA DOMINGENSIS Spreng.

This West Indian *Gerardia* was found growing in great abundance in the low pinelands about Camp Longview and in the adjacent everglades during the spring of 1904 (*Small & Wilson 1570 & 2008*).

SPERMACOCE ASPERA Aubl.

Plants belonging to this species were found growing in abundance in hammocks between Cocoanut Grove and Cutler, Florida, by Mr. J. J. Carter and the writer in November 1903 (*no. 1207*).

DIODIA RIGIDA Cham. & Schlecht.

The pinelands between the settlement of Cutler and Black Point Creek contain many large areas of this tropical American plant. Luxuriant plants were collected there in November, 1906 (*Small & Carter 2706*).

PHORADENDRON RUBRUM (L.) Krug & Urban

The discovery of this species in peninsular Florida adds another parasitic plant to our flora. Flowering specimens were collected at Deep Lake Florida, March 7, 1905, by Mr. A. A. Eaton (*no. 1310*).

**Melanthera radiata** sp. nov.

Stems several or many from a thick root, radially spreading, decumbent, 2–4 dm. long, simple or sparingly branched, sparingly

appressed-pubescent: leaves opposite; blades ovate in outline, 1–4 cm. long, more or less distinctly hastate-lobed and irregularly toothed, rough-pubescent, short-petioled: heads long-peduncled: involucres not foliaceous; bracts ovate to oblong-ovate, not surpassing the disk, the outer ones 6–7 mm. long, ciliate and pubescent: bractlets 6–7 mm. long, ciliate at the tips: corollas 6.5–8 mm. long; tube sparingly pubescent above; lobes ovate, ciliate: achenes 2.5–3 mm. long, slightly broadened upward, very minutely papillose, with a prominent tip over each side: pappus-bristles deciduous, longer than the achene.

*Melanthera radiata* is most closely related to *M. aspera* (Jacq.) Steud. (*M. deltoidea* Michx.) from which, however, it differs conspicuously in habit, the several or many stems arising from a thick, woody root, spreading radially, and decumbent. The leaf-blades too are small and very short-petioled and with sharp teeth. The type specimens were collected in pinelands near the homestead trail near Camp Longview, Florida, May 13–16, 1904 (*Small & Wilson 1575*).

# Some aspects of the mycorhiza problem *

BENJAMIN C. GRUENBERG

The roots or underground stems in many families of plants exhibit the constant presence of a symbiotic fungus. Mycorhiza has been described in liverworts and ferns as well as in over twenty families of flowering plants, including gymnosperms, monocotyledons, and dicotyledons. With very few exceptions, mycorhiza is not characteristic of the plants of a whole family, that is, in most families of plants examined, some species have the mycorhiza, and some have not. There are even species of plants in which the presence or absence of the root fungus seems to be determined by external conditions; symbiosis is facultative, so far at least as the phanerogam is concerned.

The identity of the fungus in the mycorhiza has been the subject of many investigations, but has not been definitely determined for more than a very few cases, and even in these not with satisfactory certainty. The chief difficulties in the way of identifying the mycorhiza fungus lies in the fact that the mycelium cannot be readily isolated and made to sporulate. The frequent finding of *Fusarium* forms in cultures of mycorhiza fungus leads to the suspicion of foreign contamination. The spores of *Penicillium* are common in the soil and various moulds frequently appear in cultures even after great pains have been taken to free specimens from adhering soil particles or other foreign matter. All groups of fungi, from bacteria and slime-moulds to Pyrenomycetes and agarics have been declared to form the mycorhiza in different plants by different observers. It is impossible to identify the fungus from the mycelium alone, although recent examinations of forest trees have shown the presence of characteristically colored mycelia which were believed to be connected with sporocarps in the vicinity.

As to the relationship between the fungus and the higher plant

* Read before Section G of the American Association for the Advancement of Science at the Baltimore Meeting, December 31, 1908.

(commonly called the host although it is not commonly supposed that the relationship is a parasitic one) there have been offered many theories. In 1846 Reissek declared that the root fungus was a normal phenomenon in the life of the plant, like the production of flowers: it is not necessary to the existence of the plant but is produced under certain conditions, spontaneously. Schacht in 1852 and Irmisch in 1853 described the fungus in many orchid roots and rhizomes and concluded that the fungus was not parasitic, but offered no definite explanation of the constant presence of the fungus in the orchid.

In 1877 Pfeffer suggested that as root hairs were absent from the roots or rhizomes bearing fungi, the fungi perform the absorbing function of root-hairs. In 1882, Kamienski, studying *Monotropa*, concluded that the relation between this plant and its root fungus is a mutual symbiosis, and in 1885 Brunchorst ascribed a similar nutritive function to the symbiont of the Papilionaceae. In 1886 Müller inferred from the behavior of the roots of forest trees that the fungus serves to disintegrate the soil. Frank in 1888 thought that the root fungus is of special service to its symbiont in absorbing nitrogen compounds from the soil, or from the humus. It has since been definitely determined that the organisms in the root-tubercles of leguminous plants, as well as other fungi, have the ability to fix atmospheric nitrogen, and this capacity is of sufficient advantage to compensate for any carbohydrate the fungus may obtain from its partner.

There is probably no need to consider, nowadays, some of the earlier theories of spontaneous generation of autonomous organisms within the tissues of the seed plant; or the idea that the fungus-infested tissue is the result of degeneration or the gall of an insect. All the probabilities point to some nutritive relation between two autonomous organisms, including under the concept "nutritive" water and salt relations. However, there is no reason to assume that the mycorhiza has the same significance in all cases.

Our ordinary ideas of mutual symbiosis fail when we come to consider the case of plants entirely free from chlorophyl. The case of *Monotropa* was interpreted by Kamienski as follows: The *Monotropa* derives its organic nutrients from the humus through the intermediation of the fungus, which obtains from the

*Monotropa* a convenient substratum. Formally, this interpretation explains the relation well enough, but it is not certain that that is all there is to the matter. In several species of *Corallorhiza*, the coral-root orchid, chlorophyl is entirely absent, and the leaves are reduced to a few inconspicuous, sheathing scales. Nevertheless these plants contain large amounts of starch in the underground portions as well as some in the scape and in the floral organs.

We may account for the presence of starch in these plants in the same way as we account for it in the underground portions of a green plant, that is, we may say that it has been condensed from sugar. The real problem in the coral-roots is, how do they get their sugar? Many authors have described these plants and others without chlorophyl as having no stomata; this may have been due to faulty observation, or to *a priori* reasoning from the absence of chlorophyl, or to biased observation. The fact remains that in all species of *Corallorhiza* examined by the writer, stomata are well developed in all parts of the plant, including floral envelope and rhizome. On the latter, the stomata are frequently clogged with earth, but there is no doubt as to their presence. The absence of all absorbing organs has also been declared to be characteristic of these plants. But there is present on each internode of the rhizome a whorl of tiny papillae which are found to bear tufts of fine hairs that may well serve as root-hairs in the absorption of soil water. These trichomes are very delicate and easily destroyed in removing the rhizome from the adhering soil, but they may be easily found by washing the soil off in several changes of water.

Now, the plant having been provided with stomata and absorbing organs, it may be supposed that the organism is prepared to manufacture its carbohydrates in the orthodox fashion, since it has some chromoplasts in the parts above ground. But the area exposed to the light is very small, in comparison with the bulk of the subterranean portion, and the absorbing surface is also very small. Still these facts could not be taken in themselves to preclude the possibility of photosynthesis. A vigorous specimen of *Corallorhiza multiflora* growing in a pine grove was examined for starch by scraping off the skin at several points and treating with dilute

solution of iodine in potassium iodide. The plant was covered over with a light-tight box and left this way for several days. On re-examining the subepidermal regions for starch, no difference in the apparent abundance of this substance could be observed. That the plant does not obtain its carbohydrate synthetically I feel convinced.

The only other direction from which it may come is the soil. The constituents of the humus that may yield carbohydrates, the means for their absorption, and the mechanism for their conversion into starch remain to be determined.

The question of the entry of the fungus into the rhizome is another open problem. The seeds of orchids are notoriously indifferent to all efforts to coax them into germination, and without seedlings free from the fungus it is hopeless to find the complete analysis of the relation between the symbionts. In many mycorhizas there have been found hyphal connections between the endotropic mycelium and external mycelia. But in very many cases absolutely no trace of such connection can be found. In *Corallorhiza* the mycelium of the cortical layers frequently sends hyphae singly or in bundles into the trichomes on the papillae, but it is not certain that these hyphae regularly reach the exterior. With the exception of the trichomes, the epidermal cells are uniformly free from hyphae. It has been supposed that the fungus gains entrance through the stomata of the rhizome; it would be necessary to find seedlings free from the fungus, and stomata through which the hyphae could be seen to pass. I have searched for both and have found neither.

If the orchid is absolutely dependent upon the fungus for its nutrition, how may the seedling develop without the fungus? The embryo of the orchid seed is undifferentiated, and the nutrients stored within the seed could not carry the plant along very far. But the ripened seeds are ordinarily free from fungus; at any rate fungal threads are not present in every seed, and it has been impossible to grow from the seeds any fungus that at all resembles the fungus of the mycorhiza. Moreover, the scape, through which any connection between the mycorhiza and the seed would have to pass, is generally quite free from mycelial threads.

The mycorhiza problem is not only of great interest theoret-

cally, but may have important practical bearings upon the transplanting of trees, reforestation problems, tuberization, nitrification of the soil etc.

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# INDEX TO AMERICAN BOTANICAL LITERATURE
## (1908)

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in its broadest sense.

Reviews, and papers which relate exclusively to forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included, and no attempt is made to index the literature of bacteriology. An occasional exception is made in favor of some paper appearing in an American periodical which is devoted wholly to botany. Reprints are not mentioned unless they differ from the original in some important particular. If users of the Index will call the attention of the editor to errors or omissions their kindness will be appreciated.

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